SOIL TEMPERATURES AT CAPE HALLETT, ANTARCTICA, 1958

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[Manuscript received April 11, 1960; revised June 27, 1960]

ABSTRACT

Soil temperatures at 10- and 50-cm. levels were obtained at Cape Hallett from April through December 1958. The instrumentation used is described and graphs and tables of the results obtained are presented.

1. INTRODUCTION

Hallett is one of the few Antarctic stations not located on a snow field. It was believed, therefore that a sampling of subsurface temperatures there would add to the general geophysical knowledge of Antarctica. During 1958, soil temperatures were recorded at depths of 10 and 50 cm. at Cape Hallett, Antarctica. A third level, at 100 cm., was contemplated and a thermohm installed. Unfortunately, bulldozing operations severed the lead-in cable and covered it with compacted fill. The break was not noticed until it was too late for salvage operations.

The Cape Hallett station, operated jointly by New Zealand and the United States during the IGY, is located on a sandy and rocky spit jutting westward from the headland that comprises Cape Hallett (fig. 1). This headland is the southern terminus of Moubray Bay, an extension of the Ross Sea. The spit, which comprises about 40 acres, extends westward from the cape into Hallett Bay in a broad, comma-like configuration. Highest elevation above mean sea level is approximately 15 feet, located close to the northern and western shore line. The main camp buildings are located on this high ground (see fig. 2).

The soil of the spit is sandy with a plentiful supply of rocks and pebbles. The entire area is a penguin rookery and it can be assumed that the soil also consists of consolidated penguin carcasses. It is regretted that a soil analysis is not available for inclusion with this report.

2. INSTRUMENTATION

Figure 3 is a schematic of the instrument complex and shows the relative positions of the various meteorological instruments. The thermohms were placed horizontally in a small, shallow pit. Singer and Brown [1] placed their thermohms vertically, otherwise the installation is similar. Care was taken to replace material in the order in which it had been before. Cable from the thermohms to the recorder was of the lead shielded type and necessary junctions were soldered and insulated.

The primary function of the recording device available, a Leeds and Northrup single-point, curve-drawing recorder, was to measure ambient air temperature. A three-pole switch was installed, permitting air temperature to be recorded continuously except for switching to obtain soil temperatures at standard synoptic observation times.

To establish recorder reliability, the check coil provided with the instrument was inserted periodically. The balance, at −80° F., was obtained at the right-hand edge of the trace. When outside temperatures permitted, the air temperature thermohm was inserted into a bath of water and ice and the temperature noted. The right-

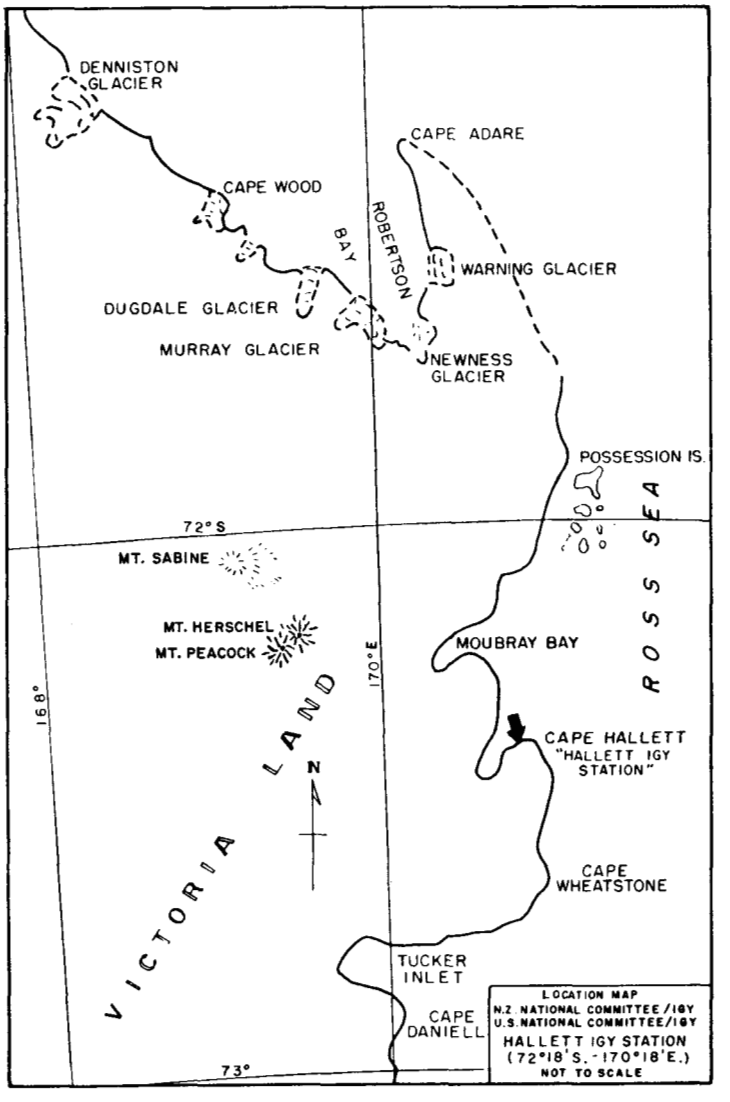

FIGURE 1.—Map of Cape Hallett area, Antarctica.

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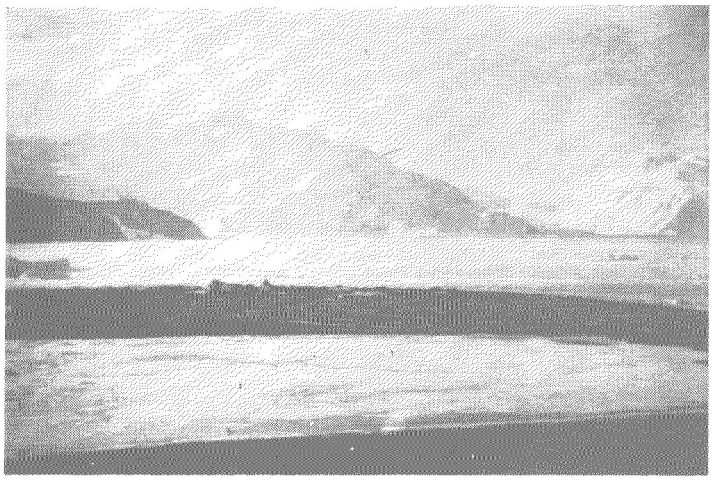

FIGURE 2.—View from eastern hills of sandspit on which Hallett station is located. Camp buildings can be seen in the center, Mount Herschel in the background.

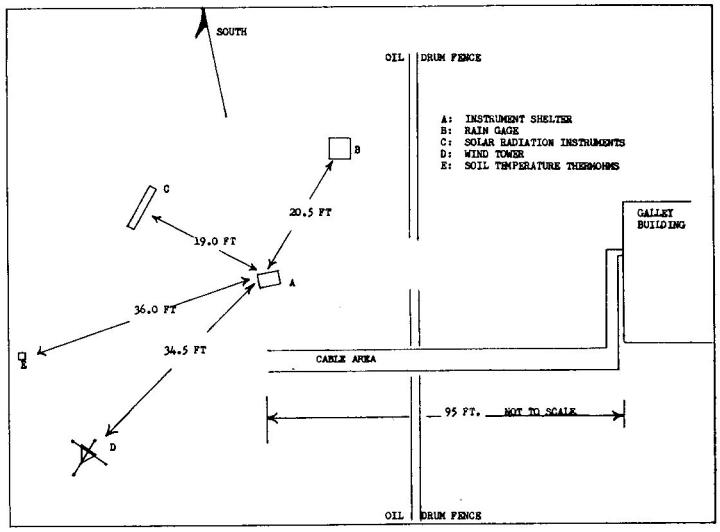

FIGURE 3.—Plan showing location of meteorological instruments at Hallett station, 1958.

hand edge of the trace indicated 32.0°. It was assumed that the readings were similarly accurate over the entire range of the recorder.

3. AIR AND SOIL TEMPERATURES

The mean daily air and 10- and 50-cm. soil temperatures are displayed in tables 1–3. Monthly graphs of the mean daily air temperature and of the soil temperatures are provided in figure 4.

Figure 5 is a graph of the mean monthly air and soil temperatures for the period April through December 1958. Examination of the two soil temperature traces in figure 5 reveals two differing values for the month of August. The warmer of the mean temperatures is for the period prior to removal of the accumulated snow drift over the thermohm installation. Beginning around the end of March, drifting and falling snow began to accumulate. Rate of accumulation was sporadic, however, depending on storm frequency and intensity. The drifts increased gradually; each storm added several inches followed by a period when the depth was relatively constant.

TABLE 1.—*Monthly mean air temperature (°F.) Hallett, Antarctica, April–December 1958.*

	1958								
	April	May	June	July	August	September	October	November	December
1	11.5	−0.5	−10.5	−3.0	−1.0	−11.0	−12.0	2.5	21.5
2	13.5	−6.5	−10.0	0.5	−8.0	−22.0	−10.5	2.0	18.5
3	10.5	−11.5	−14.0	−8.0	−9.5	−26.0	−15.0	1.0	20.5
4	10.5	−9.0	−23.0	−20.0	−7.5	−26.0	−24.0	9.5	22.0
5	12.0	−3.0	−13.0	−27.5	−8.5	−27.0	−10.0	13.0	20.0
6	13.5	−4.5	−4.5	−25.5	−18.0	−21.5	−4.0	11.5	18.5
7	13.5	−5.5	−11.5	−20.5	−13.0	−21.5	−3.5	12.5	24.5
8	14.5	3.5	−9.0	−25.0	−16.0	−25.5	−5.0	15.5	24.5
9	12.5	−7.0	−13.5	−32.0	−21.0	−27.0	−0.5	15.5	25.0
10	19.0	−11.5	−9.5	−31.5	−17.0	−21.0	−1.0	10.0	23.0
11	19.0	−13.0	−14.0	−18.5	−8.0	−23.0	6.0	15.5	22.0
12	12.0	−14.0	−11.5	−18.0	1.5	−24.0	1.5	17.0	24.5
13	4.0	−15.5	2.0	−20.0	10.0	−17.0	−2.5	19.0	23.5
14	6.5	−13.5	5.0	−16.0	−3.5	−19.0	−4.0	20.5	30.5
15	8.5	−18.0	1.0	−23.0	−16.0	−18.0	−2.5	18.0	30.5
16	1.0	−7.0	−3.5	−30.0	−16.5	−7.5	−6.5	22.5	29.0
17	−4.5	−2.5	−2.5	−18.0	−15.5	−12.5	0.5	19.0	28.5
18	−9.5	−7.5	−5.5	−15.0	−12.0	−15.0	−6.5	16.5	27.5
19	−9.0	−7.0	−11.0	−25.0	−11.0	1.5	−10.0	20.0	26.5
20	−1.5	−8.5	−17.5	−22.0	−21.5	−10.5	−11.5	17.5	26.5
21	−1.5	−18.5	−20.5	−22.5	−21.5	−21.0	−11.5	17.5	26.5
22	−1.0	−19.0	−27.0	−25.0	−32.0	−7.5	0.0	17.5	26.0
23	2.0	−23.5	−17.5	−27.5	−29.5	−4.5	2.5	17.0	23.0
24	9.0	−21.5	−8.0	−26.5	−16.0	−3.5	8.5	16.5	29.0
25	9.0	−23.0	−9.0	−19.0	−11.5	−3.5	9.5	22.5	31.5
26	0.5	−17.0	−12.0	−20.5	−19.5	−7.5	4.5	21.5	30.0
27	2.0	−15.5	−15.5	−27.0	−14.0	−5.5	6.0	19.5	27.0
28	7.5	−18.0	−4.0	−26.5	−14.0	−6.5	14.5	17.0	29.5
29	2.5	−5.0	9.5	−5.5	−20.5	−4.5	13.5	22.0	28.5
30	−5.5	−5.0	3.5	5.5	−21.0	−8.0	12.0	22.0	28.0
31		−17.5		−1.0	−12.5		7.5		27.0
Sums	182.0	−345.5	−276.5	−593.5	−424.0	−445.3	−55.5	471.5	798.0
Means	6.1	−11.1	−9.2	−19.2	−13.7	−14.9	−1.8	15.7	25.7

TABLE 2.—*Monthly mean 10-cm. soil temperature (°F.), Hallett, Antarctica, April–December 1958.*

	1958								
	April	May	June	July	August	September	October	November	December
1		2.6	−14.7	−1.2	−5.3	−13.8	−16.8	1.6	29.2
2		1.3	−10.2	−0.5	−5.3	−20.1	−16.4	0.5	29.8
3		−2.5	−10.0	0.1	−5.1	−25.1	−17.7	−1.4	30.7
4		−3.2	−11.7	0.2	−5.0	−27.7	−21.3	−0.8	31.3
5		0.1	−10.3	0.5	−5.0	−27.6	−19.3	0.3	32.2
6		0.6	−8.4	1.3	−4.8	−26.1	−14.3	0.9	34.9
7		0.6	−7.1	0.6		−25.6	−12.5	2.1	32.9
8		0.8	−7.1	0.2		−27.5	−10.7	3.5	33.9
9		−1.9	−7.6	0.0		−27.4	−9.4	4.4	34.9
10		−3.8	−8.1	−0.6		−24.4	−7.9	4.1	36.6
11		−3.6	−8.7	−1.3		−27.2	−0.9	3.8	36.8
12		−4.8	−9.8	−1.6		−27.8	−4.8	4.6	36.9
13		−8.3	−4.9	−2.1		−22.5	−7.2	5.4	39.5
14		−10.3	−1.8	−2.4		−21.1	−6.3	6.9	39.8
15		−11.3	−1.2	−2.7		−21.0	−6.2	8.2	43.3
16		−10.5	−0.9	−2.9		−15.0	−9.5	9.8	43.8
17		−8.7	−1.0	−3.0		−15.5	−4.3	10.6	44.9
18		−6.5	−1.8	−3.1		−19.7	−2.6	11.0	41.5
19		−7.7	−1.0	−3.3		−12.3	−6.7	11.2	37.9
20		−9.6	−1.1	−2.9		−9.9	−8.2	11.1	34.3
21	0.1	−11.6	−1.1	−3.0		−19.4	−8.5	11.1	33.2
22	0.4	−12.8	−1.5	−3.1	−27.1	−9.8	−4.8	11.9	34.2
23	2.3	−15.2	−1.8	−3.6	−28.8	−6.7	−2.4	22.3	36.8
24	4.3	−16.4	−2.6	−4.1	−22.0	−10.4	−0.5	32.0	37.5
25	3.2	−22.0	−3.0	−4.3	−17.0	−7.6	1.4	32.1	37.1
26	3.0	−18.2	−2.9	−4.7	−19.3	−13.4	3.6	32.0	37.7
27	0.9	−15.3	−2.7	−4.7	−18.6	−9.8	1.2	31.9	37.0
28	5.3	−16.5	−2.7	−5.6	−17.6	−12.3	4.9	31.6	37.6
29	5.7	−14.3	−2.6	−5.0	−21.5	−11.1	3.9	30.0	36.1
30	2.7	−9.7	−1.9	−5.7	−22.8	−14.1	2.3	29.4	33.4
31		−13.6		−5.1	−16.9		2.2		31.6
Sums	27.9	−252.3	−149.9	−73.6	−211.6	−551.9	−199.7	−362.1	1117.3
Means	2.8	−8.1	−5.0	−2.4	−21.2	−18.4	−6.4	12.1	36.0

TABLE 3.—*Monthly mean 50-cm. soil temperature (°F.), Hallett Antarctica, April–December 1958.*

	1958								
	April	May	June	July	August	September	October	November	December
1		8.9	−2.7	0.0	−1.4	−10.8	−9.6	−0.8	22.9
2		8.8	−2.9	−0.2	−1.9	−10.4	−12.1	−0.4	23.0
3		8.2	−2.8	0.8	−1.8	−11.1	−11.8	−0.9	23.7
4		7.8	−2.6	0.8	−1.9	−12.2	−10.9	−1.2	24.2
5		7.0	−2.9	0.8	−2.2	−13.2	−11.2	−1.1	24.7
6		7.2	−2.9	1.1	−2.5	−13.8	−11.1	−0.7	25.3
7		7.2	−2.5	1.6	−11.7*	−14.0	−10.3	−0.3	25.8
8		7.1	−2.2	1.6	−2.0*	−14.2	−9.6	−0.1	26.0
9		6.2	−2.1	1.7		−14.7	−9.1	0.5	26.3
10		6.5	−2.2	1.7		−14.8	−8.7	1.3	26.5
11		6.1	−2.4	1.0		−14.9	−7.5	1.6	26.7
12		5.7	−2.5	1.4		−15.3	−6.3	1.8	27.2
13		5.2	−2.1	1.2		−15.4	−6.4	2.3	27.3
14		4.4	−2.2	1.0		−14.7	−6.6	2.9	27.7
15		3.5	−1.1	0.9		−14.5	−6.2	3.4	28.0
16		2.9	−0.8	0.7		−13.5	−4.9	4.2	28.1
17		2.3	−0.6	0.3		−12.9	−6.3	5.1	28.9
18		2.2	−0.1	0.1		−12.8	−5.7	5.8	29.0
19		2.0	0.1	0.1		−12.8	−5.3	6.2	29.1
20		1.9	0.0	0.6		−11.4	−5.8	6.8	29.4
21	8.4	1.6	0.1	0.6		−11.1	−6.2	6.9	29.1
22	8.5	1.0	0.3	0.3	−9.1	−11.7	−6.1	7.2	29.0
23	8.1	0.3	0.2	−0.1	−10.5	−10.2	−5.6	15.7	29.0
24	8.8	−0.4	0.4	−0.6	−11.3	−9.0	−4.8	21.2	29.1
25	9.1	−1.2	0.3	−0.8	−11.1	−9.1	−3.7	22.4	29.3
26	8.9	−2.0	0.2	−0.6	−10.4	−8.9	−2.9	22.8	29.4
27	9.0	−2.2	0.6	−1.2	−10.7	−9.2	−2.6	23.0	29.4
28	8.8	−2.5	0.3	−1.0	−10.7	−9.0	−2.1	22.9	29.6
29	8.8	−3.0	0.3	−1.1	−10.3	−9.1	−1.2	23.1	29.8
30	9.0	−2.9	0.2	−1.1	−11.2	−9.4	−0.9	23.2	29.9
31		−2.4		−1.4	−11.3		−0.8		29.9
Sums	87.4	97.4	−34.6	9.2	−106.6†	−364.1	−202.0	225.6	853.3
Means	8.7	3.1	−1.2	0.3	−10.7†	−12.1	−6.5	7.5	27.5

*Sum and mean of first 6 days.
†Sum and mean of last 10 days.

However, the largest accumulation of snow occurred in June, the stormiest month according to Benes [2].

The decision to bulldoze the drifts was made early in August, after several days of readings were obtained. After the 4- to 5-foot drifts were removed, a sharp drop in soil temperatures was observed at both levels. At the 10-cm. level this temperature change, on a monthly mean basis, was about 16° F. At the 50-cm. level, the temperature change downward was about 8°.

It is interesting to contrast soil temperatures before

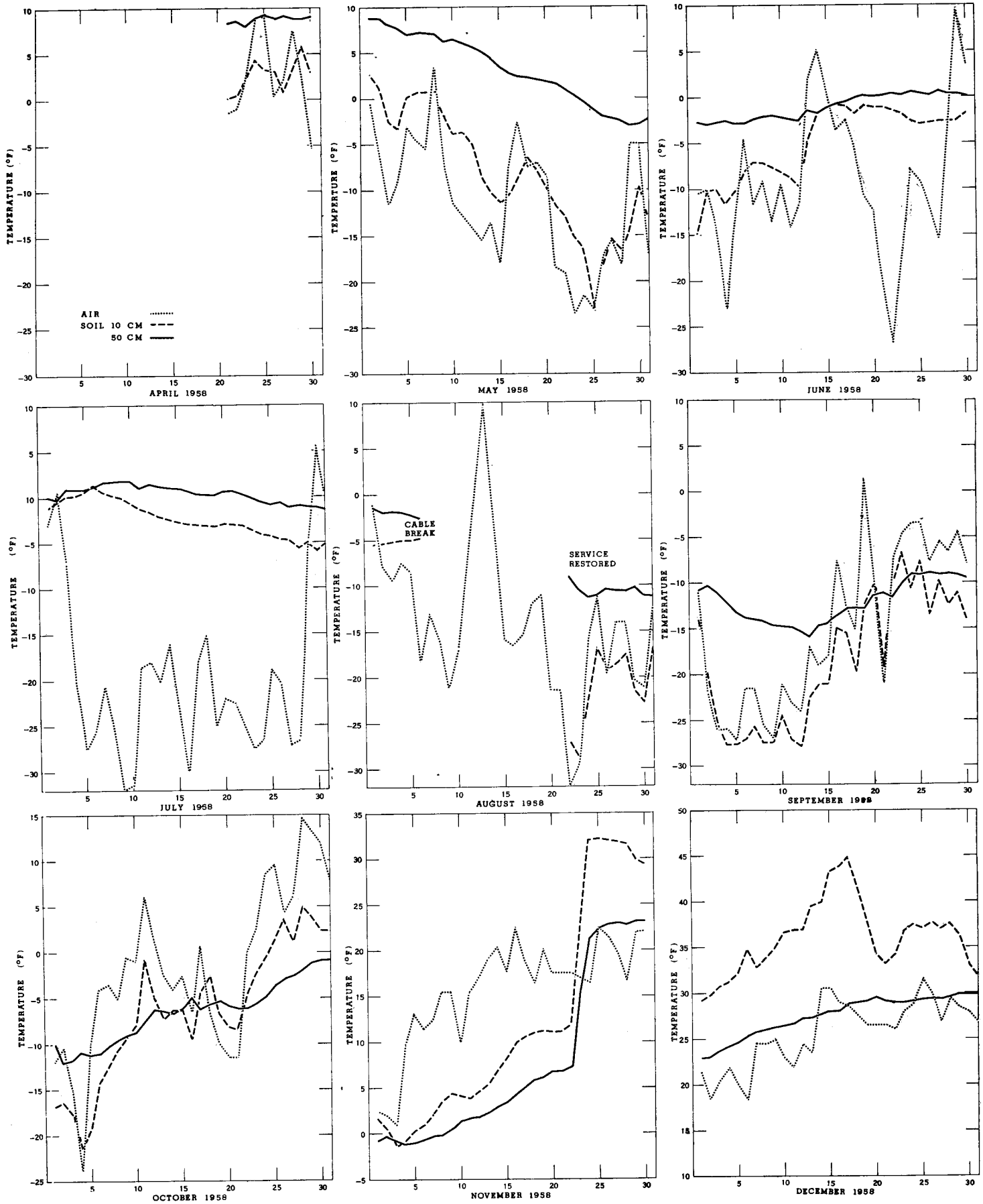

FIGURE 4.—Daily mean temperatures, both air and soil, at Hallett station, Antarctica, April–December 1958.

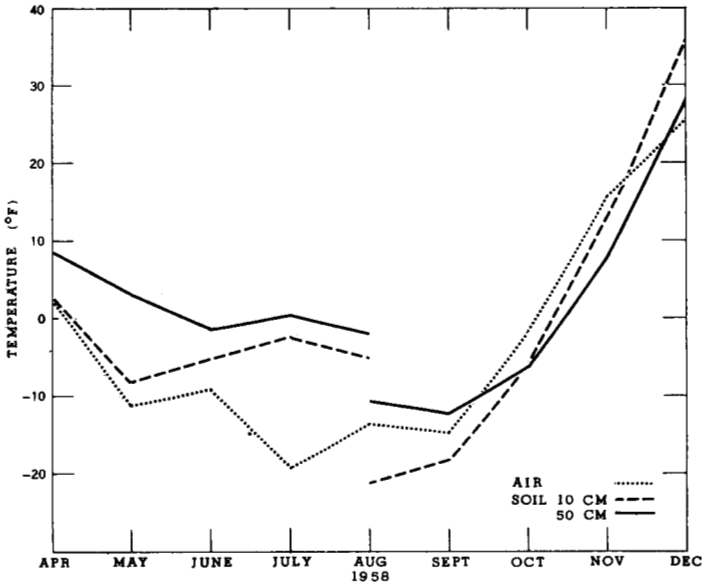

FIGURE 5.—Monthly mean temperatures, air and soil, Hallett station, Antarctica, April–December 1958.

and after drift removal. Under the deep snow cover, particularly in July (see July graph, fig. 4), while air temperature was fluctuating widely and erratically, soil temperatures were decreasing at a gradual rate. With the removal of the insulating snow, mean daily soil temperatures, particularly at the 10-cm. level, followed closely the fluctuations of air temperature. During most of the measurement period, the soil temperature curves followed the air temperature curve. Largest deviation occurred in July and the greatest warming took place at the 10-cm. depth. From September on, the trend for air and subsurface temperatures was upward; the mean monthly air and soil temperature traces then displayed a nearly linear relationship.

The tremendous increase of soil temperatures on November 22 and 23 (see November graph, fig. 4) is attributed, at least in part, to a large pool of snow melt that covered a large area and then rapidly drained into the subsoil. After this upward surge of soil temperature, the daily mean for both levels generally remained higher than the daily mean air temperature.

4. CONCLUDING REMARKS

This project was an interesting sideline to the regularly programmed schedule of observations and necessitated some improvisation to secure accurate data. It provides, in general, some knowledge of the temperature regime to be found in Antarctic soil. In addition, a first approximation of the depth of permafrost in the Cape Hallett area is provided. With data available on solar radiation, these temperatures may provide extra material for heat budget studies.

ACKNOWLEDGMENTS

The author wishes to thank Aerographers Keeler, Highlands, and Garczynski for the dial switching every six hours, and Electronic Technician Vanatta for the installation of the three-pole switch.

REFERENCES

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Weather Note

UNUSUALLY WIDE TORNADO PATH

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[Manuscript received May 6, 1960]

On April 15, 1960, between the hours of 1730 and 1830 CST a tornado traversed portions of Miami County, Kansas, and Cass County, Missouri. The purpose of this note is to describe some features of the storm path revealed by a survey of the damaged area made on April 16 and 18, 1960. The survey was accomplished by traversing all roads in the area and observing the location of damage patterns relative to the roads.

The path of the storm is shown in figure 1 and some comments on specific observations along the path are given in the caption. Three noteworthy features of the overall 14-mile-long path are: (1) its meanderings, as shown by a range of directions from 210 to 280 degrees; (2) its apparent production by at least two storms, separated from each other by a distance of ¾ to 1¾ miles with an overlap from west to east of about 2 miles; and (3) its unusual width, ranging up to a mile in the portion made by the first storm, up to 1.2 miles in the portion made by the second storm, and up to 1.4 miles across the overlapped area.

That the unusual width of the storm path resulted from more than one tornado was borne out by the testimony of several eyewitnesses who reported more than one funnel. Moreover, the width of the path, the general absence of total destruction, the abrupt shifting of winds at several points, and the discontinuity line between northerly and southwesterly winds along portions of the path suggest a circulation system larger than the individual tornado funnel. It appears that this storm may have been of the "tornado cyclone" type described by Brooks [1], the micro-cyclone type described by Williams [2], or the rotating mother cloud-tornado system described by Fujita [3].

A fuller report on the results of this storm survey is available in manuscript form [4].